

# *Evaluation of Long-term and High-resolution NLDAS Products and Their Application to Operational Drought Monitoring and Prediction*

**Youlong Xia<sup>1</sup>, Michael B. Ek<sup>1</sup>, Justin Sheffield<sup>2</sup>, Eric Wood<sup>2</sup>,  
Brian Cosgrove<sup>3</sup>, Kingtse Mo<sup>4</sup>, David Mocko<sup>5</sup>,  
Ben Livneh<sup>6</sup>, and Eric Luebehusen<sup>7</sup>**

<sup>1</sup> Environmental Modeling Center, NCEP/NOAA, Camp Springs, MD

<sup>2</sup> Department of Civil and Environmental Engineering, Princeton U, NJ

<sup>3</sup> Office of Hydrologic Development, NWS/NOAA, Silver Spring, MD

<sup>4</sup> Climate Prediction Center, NCEP/NOAA, Camp Springs, MD

<sup>5</sup> Hydrological Sciences Branch, GSFC/NASA, Greenbelt, MD

<sup>6</sup> Department of Civil and Environmental Engineering, U Washington, Seattle, WA

<sup>7</sup> USDA, World Agricultural Outlook Board, Washington DC

NASA Global Drought Monitoring Workshop, Silver Spring, Maryland, 11-12 April 2011



**This work is associated with  
three workshop objectives:**

**(1) Agricultural and hydrological drought  
products for regional applications**

**(2) Close collaboration with NASA and the  
other NLDAS partners including  
assessment and application of NLDAS  
products to operational drought monitoring  
and prediction**

**(3) Use of NASA GES DISC system to  
effectively distribute NLDAS products to  
users**



# Drought Monitoring and Prediction

Agricultural drought, hydrologic drought  
meteorological drought, etc.

Indices from precipitation, air temperature,  
soil moisture, total runoff/streamflow,  
evaporation, etc.

Evaluation of Soil Moisture  
and Streamflow

How  
Reliable?



# Evaluation of Simulated Soil Moisture



(Xia et al., JHM, 2011, in preparation)

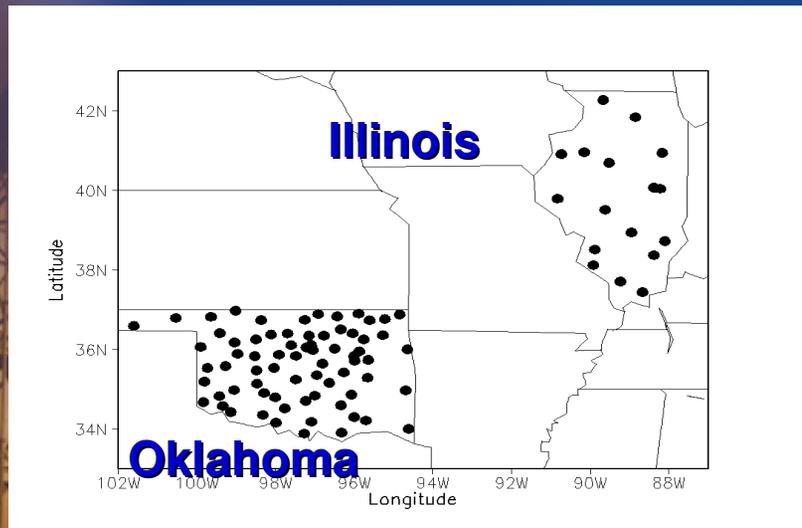
**Focus on top 1 m and 2 m soil moisture used in NLDAS monitor and operations**

Three Soil Moisture Data Sets:

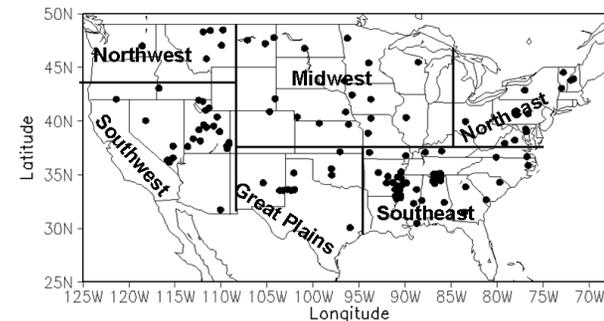
Illinois state – 17 sites, monthly, 1985-2004

Oklahoma Mesonet – 72 sites, hourly, 1997-2002

USDA/SCAN – 121 sites, daily, 2002-2009



## Soil Climate Analysis Network (SCAN)

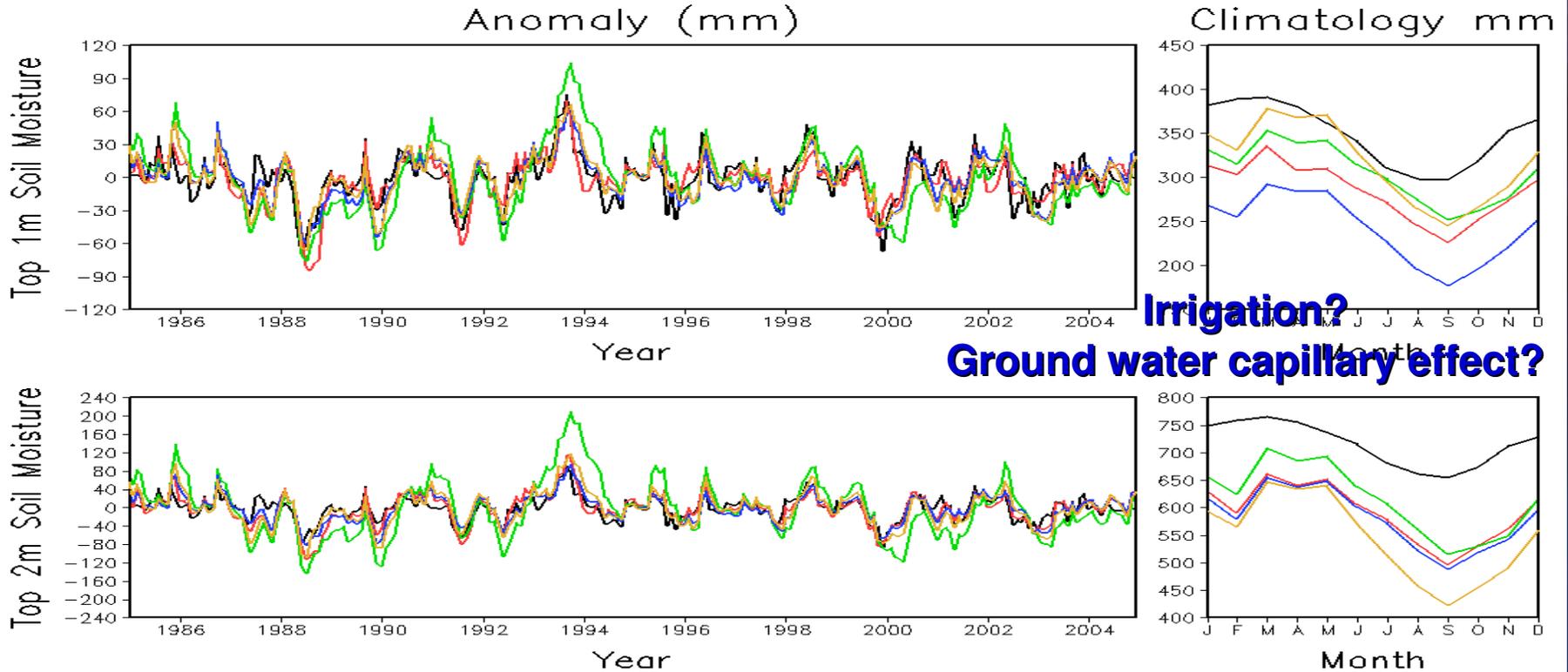


**Six regions are divided**

# Illinois



**Black line – observation** **Red line – Noah**  
**Green line – Mosaic** **Blue line – SAC** **Orange line – VIC**



## Monthly anomaly correlation for top 2 m

**NLDAS: Noah = 0.82, Mosaic = 0.63, SAC = 0.78, VIC = 0.76**

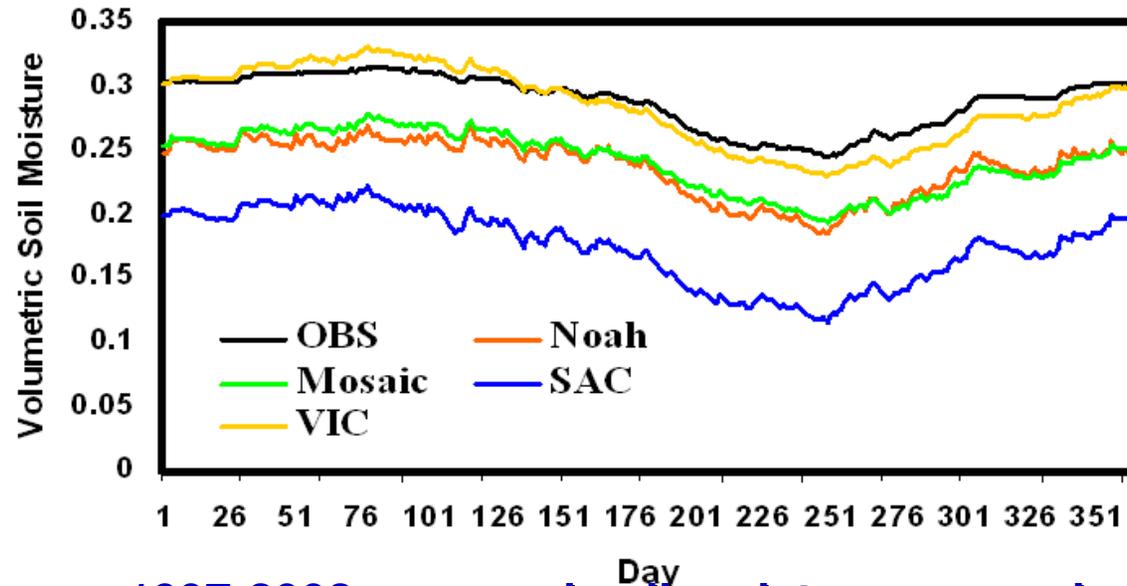
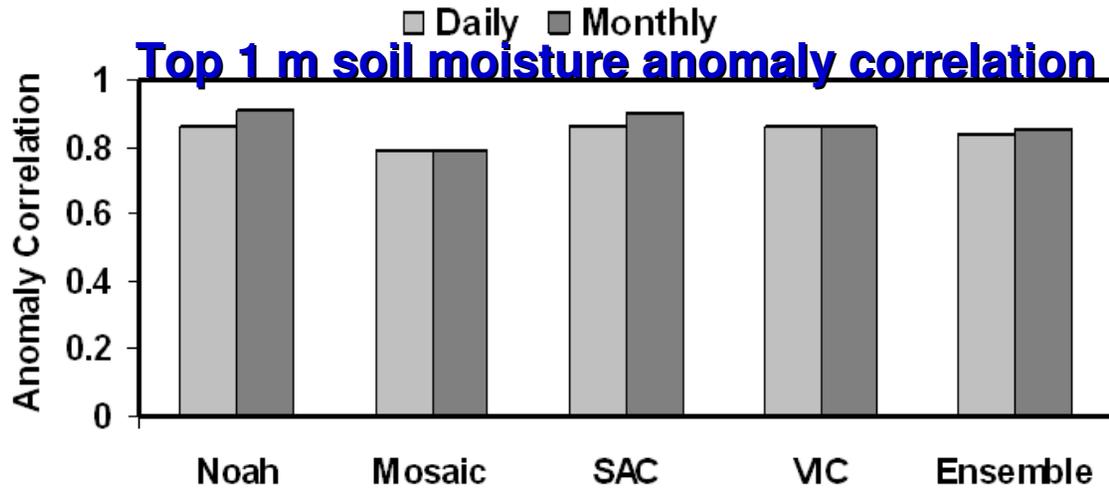
**Other NCEP Products from Noah model: GR2 = 0.47, NARR = 0.67, CFSR = 0.61**



# Oklahoma



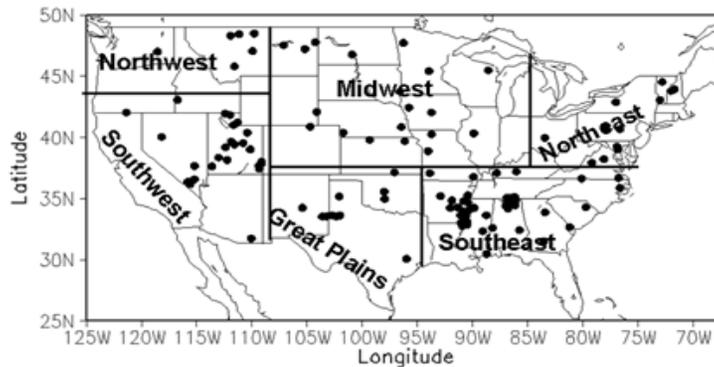
**High anomaly correlation means quite robust  
NLDAS soil moisture product**



**VIC has the smallest error, the other three models, in particular SAC, underestimate observed soil moisture, and however, all models capture daily and seasonal variation of observed soil moisture well**

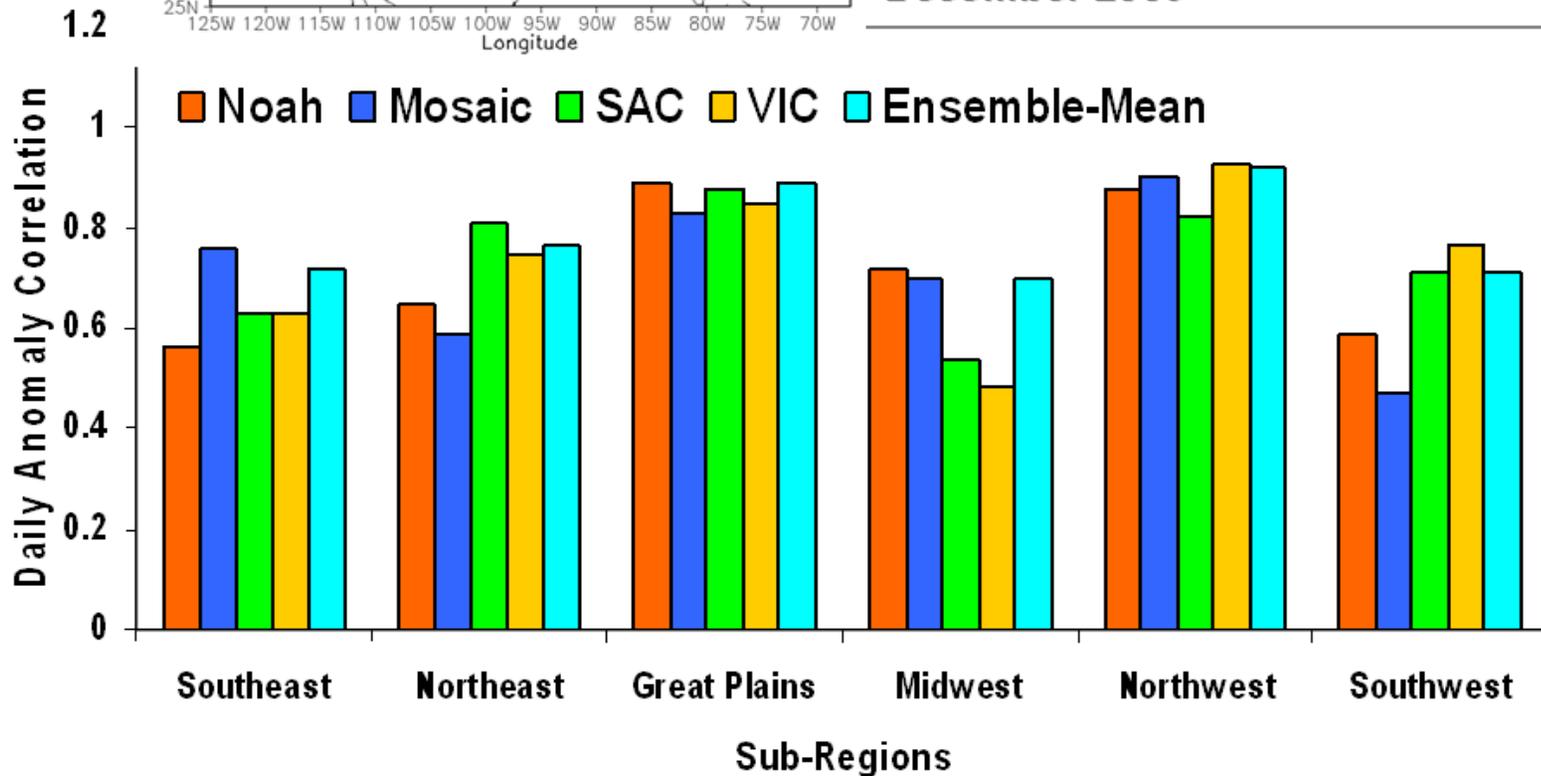


# SCAN



**Spatial averaged daily top 1m soil moisture anomaly correlation over continental United States**

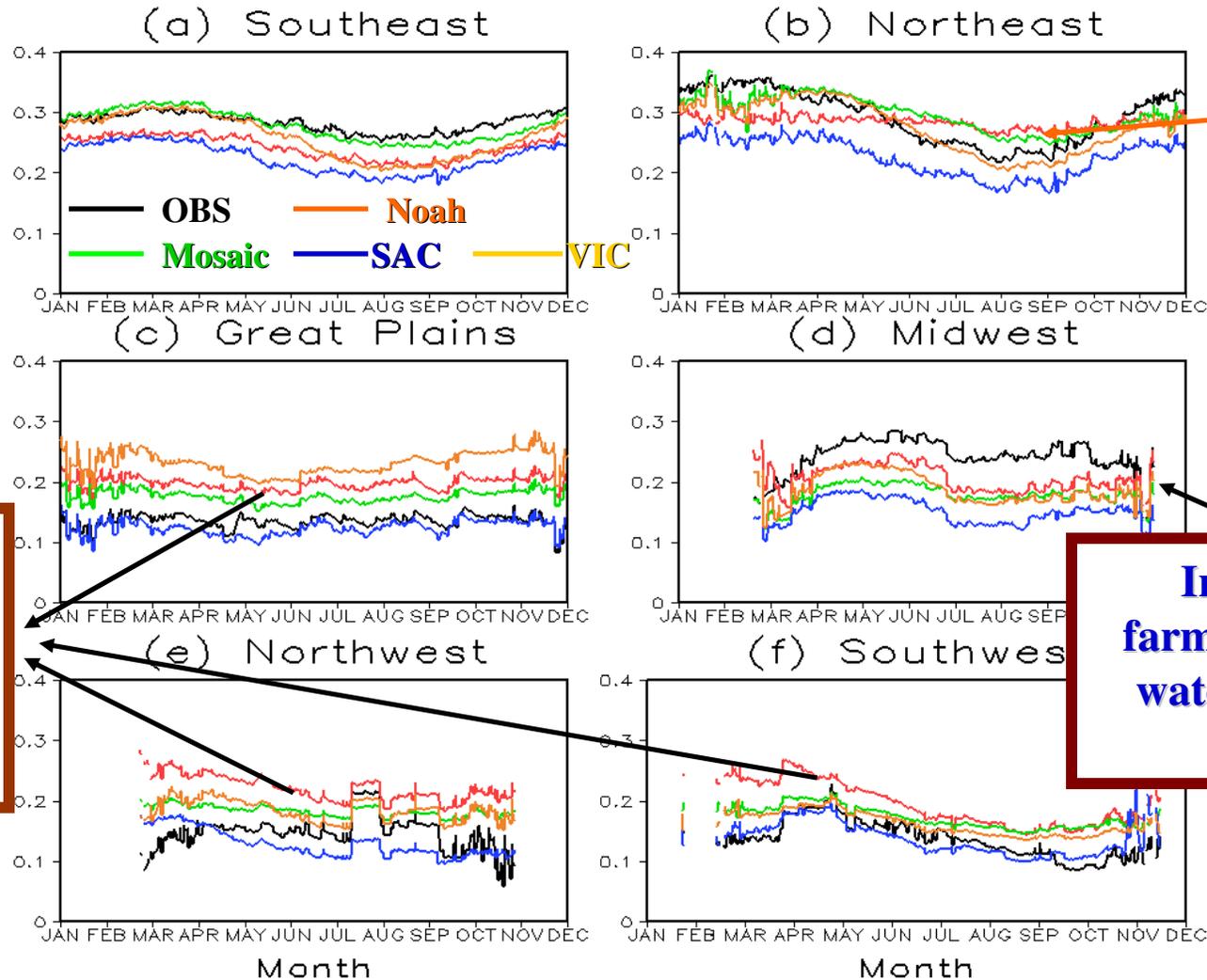
**U.S. Soil Climate Analysis Network (SCAN), 1 January 2002 - 31 December 2009**





# SCAN (Continue)

## 8-year averaged top 1 m volumetric soil moisture comparison



**Noah: low E, High R, wet soil wetness, will be fixed soon**

**Large available water holding capacity?**

**Irrigation, farming, ground water capillary effect ?**



# Evaluation of Simulated Soil Moisture Summary



- 1. All models capture variability of daily and monthly soil moisture well**
- 2. Overall performance of four-model ensemble mean is more robust**
- 3. Models indeed display biases to simulate observed soil moisture, and need to be further investigated**
- 4. NLDAS top 1m and 2m soil moisture products can be used to agricultural drought monitoring and prediction. More in situ soil moisture observations are needed for further evaluation**



# Evaluation of Simulated Streamflow

(Xia et al., JGR, 2011, submitted)

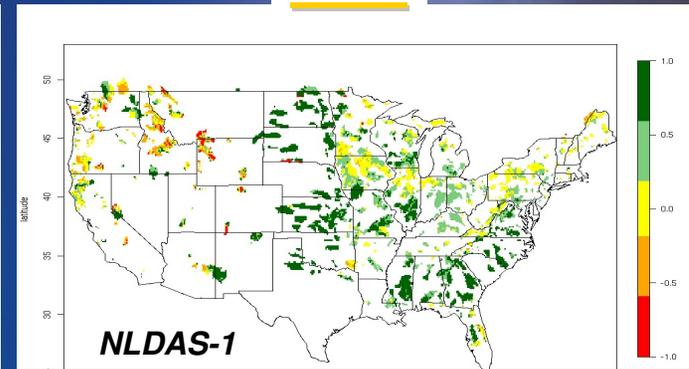
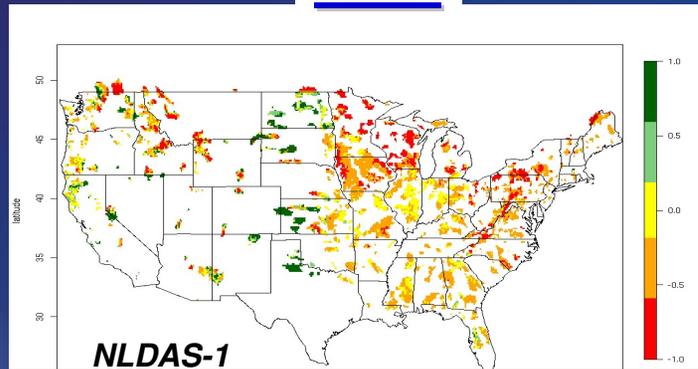
USGS Streamflow – daily, 961 small – medium size basins and 8 large basins, 1979-2007



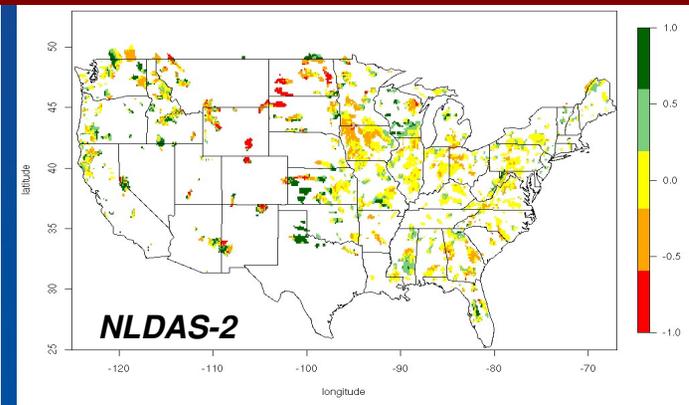
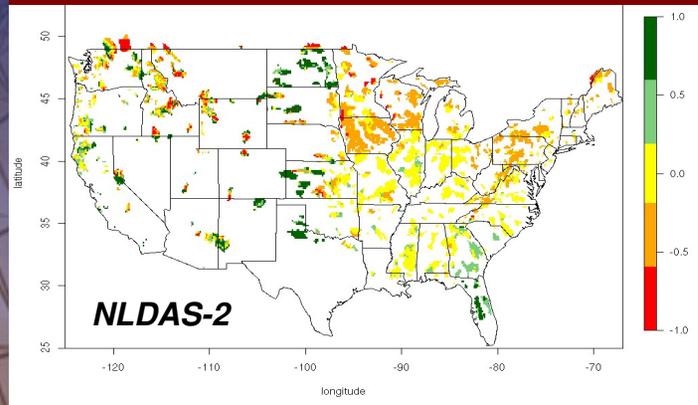
**SAC**

**VIC**

Negative bias reduced

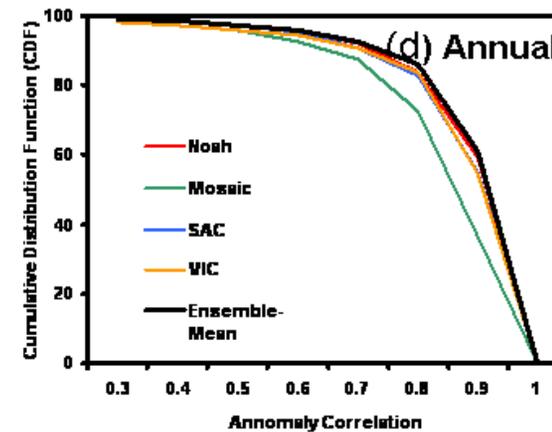
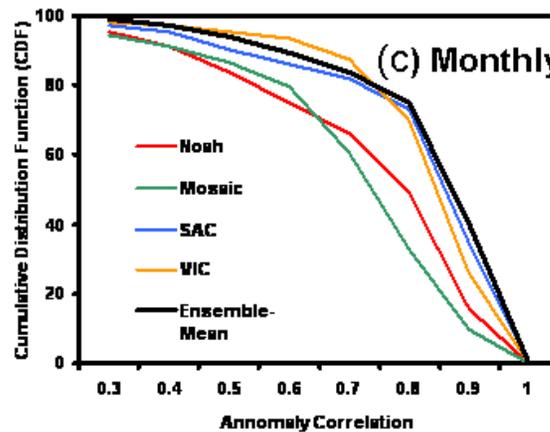
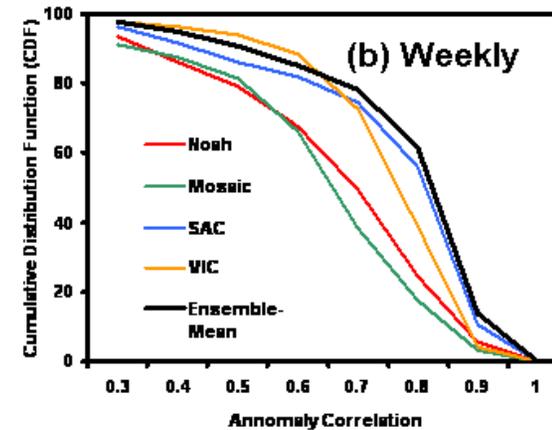
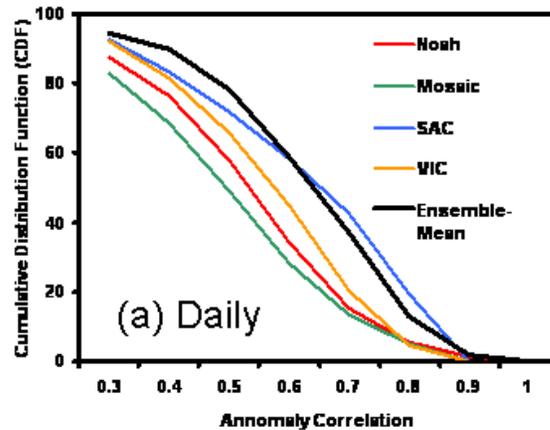


*Mean annual relative bias SIM-OBS/OBS, (OCT 1979 – SEP 2007) different model version and the same forcing*



Positive bias reduced

# Monthly Anomaly Correlation Small Basins

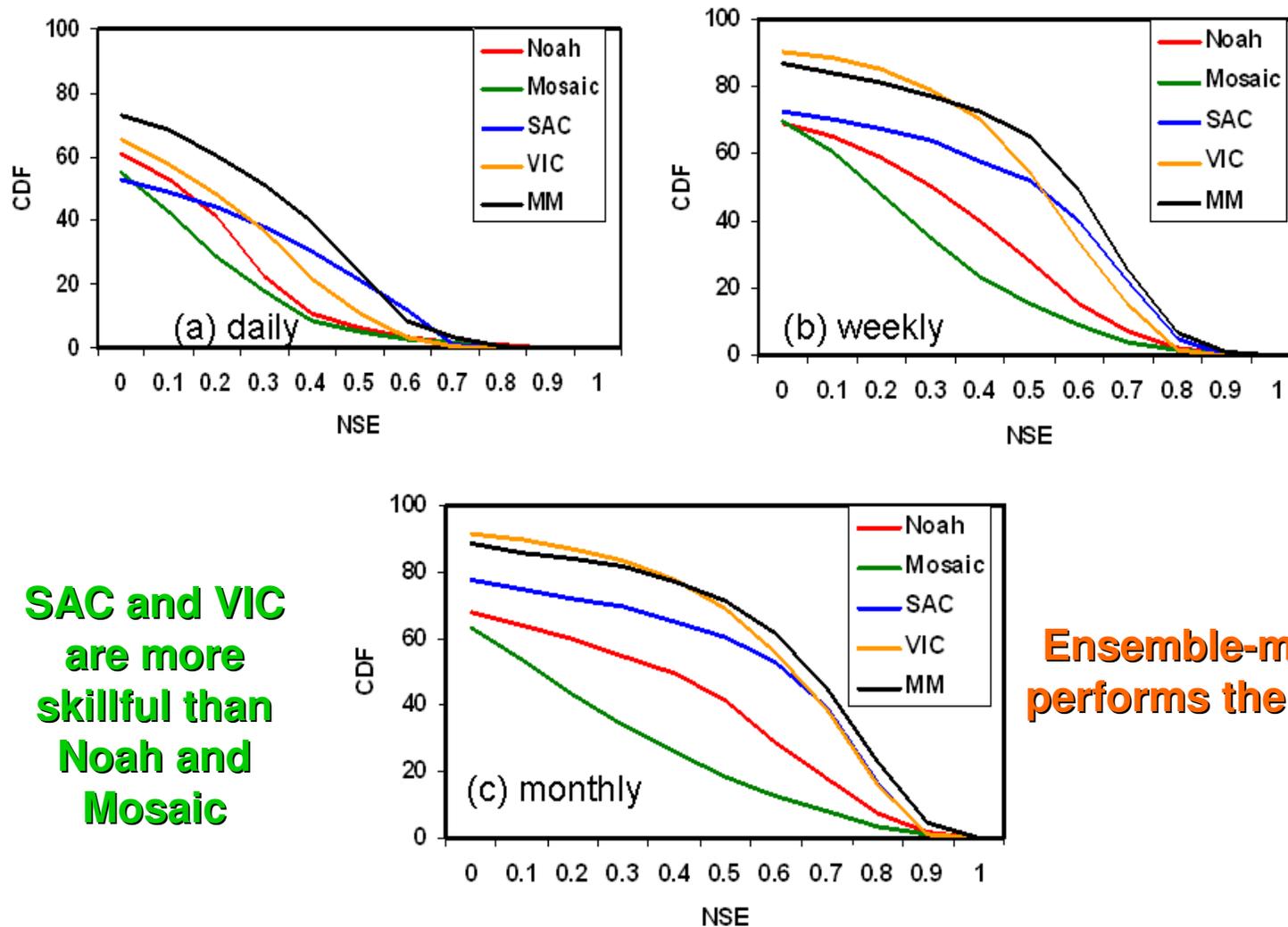


- (1) Ensemble-mean has higher simulation skill than individual model
- (2) SAC and VIC (hydrological community), perform better than Noah and Mosaic (land model community)

# Daily Nash-Sutcliffe Efficiency Small Basins



## Cumulative Distribution Function (CDF) for different time scales

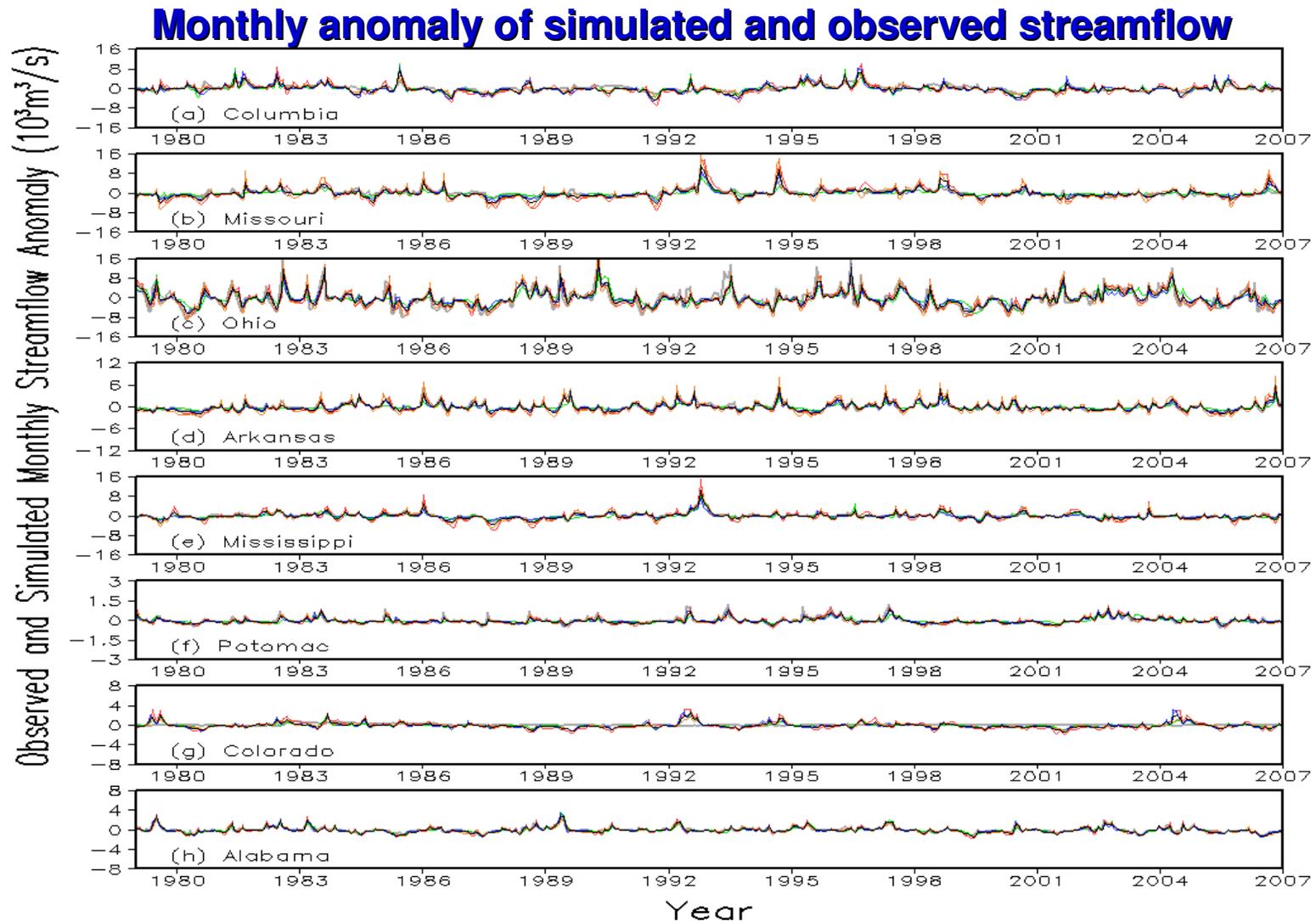


**SAC and VIC  
are more  
skillful than  
Noah and  
Mosaic**

**Ensemble-mean  
performs the best**



# Anomaly Correlation Large Basins



Gray – OBS, Black – MM, red – Noah, green – Mosaic, blue – SAC, orange - VIC

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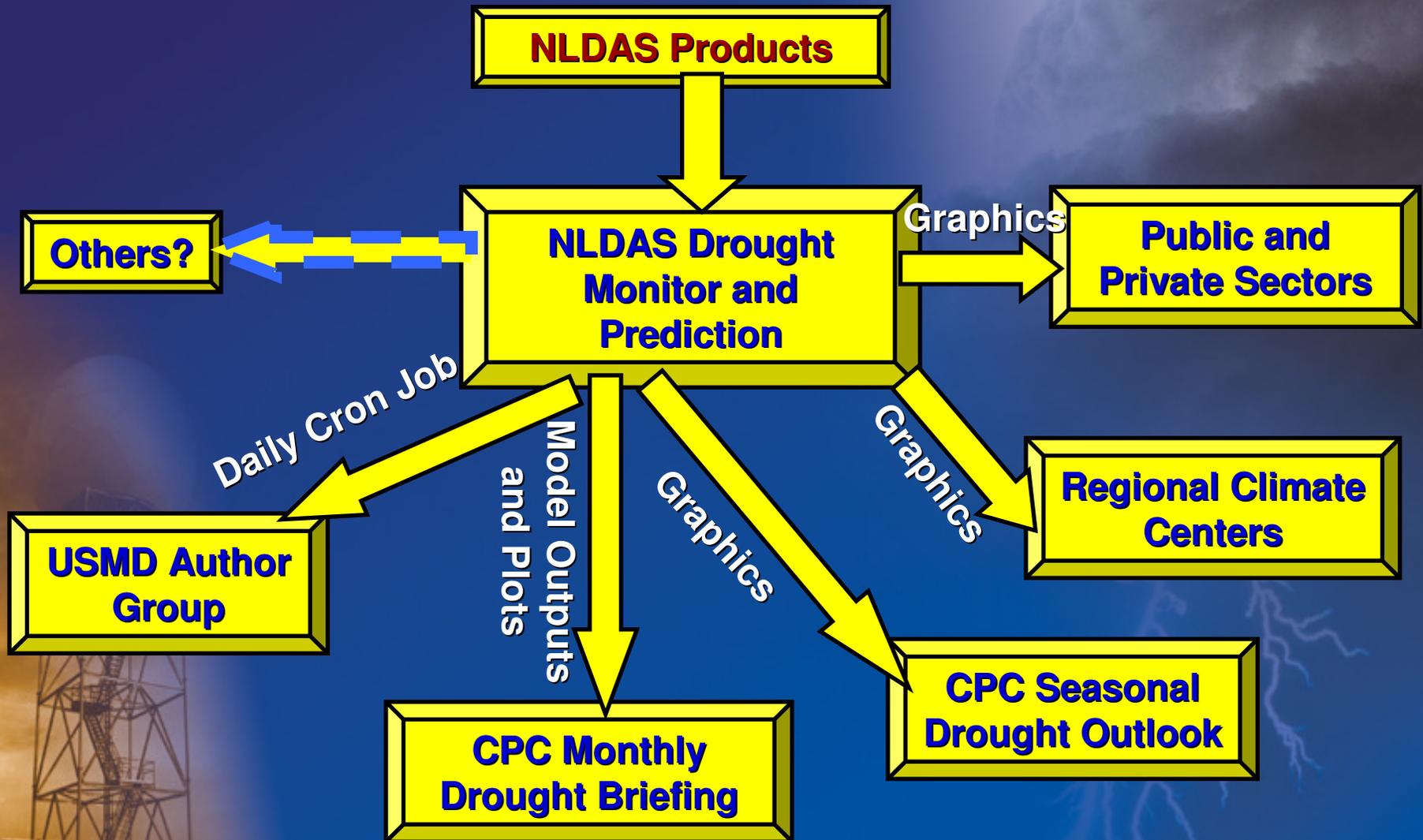
# Evaluation of Simulated Streamflow Summary



- 1. Ensemble-mean has the highest skill when compared with individual model, and hydrological models (SAC, VIC) have higher skills than land surface models (Noah, Mosaic)**
- 2. Anomaly correlation is high in the east of U.S. and western coast, and it is low in interior dry states. This conclusion is true for both small and large basins except heavily regulated Colorado basin**
- 3. NLDAS total runoff/streamflow can be used for hydrological drought monitoring and prediction for different time scales varying from day to year**
- 4. Bias between simulated and observed streamflow needs to be reduced in future by the collaboration with our NLDAS partners**



# Application to Drought Monitor and Prediction





# Summary and Future Work



**NLDAS is in quasi-operational mode now and will be transitioned to NCEP operations.**

**Further NLDAS products evaluation/validation, e.g., ET using MODIS Product, Arm/Cart, AmeriFlux**

**Extend current NLDAS to run under the NASA Land Information System (LIS) & to assimilate land-data, e.g. snow, soil moisture, etc.**

**Improve land-surface models (physics) through collaboration with NLDAS and other partners.**

**Continue to provide support for NCEP Climate Prediction Center and National Integrated Drought Information System.**



# Further Validation Underway



## Both in situ and remote sensing data

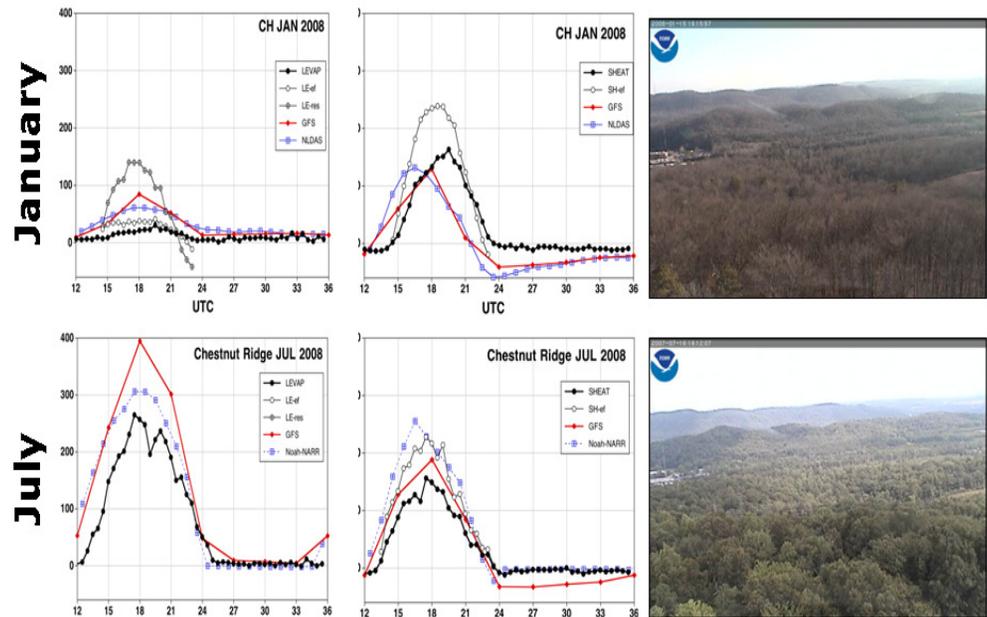
Energy flux validation  
 from tower: net radiation, sensible heat, latent heat, ground heat

Water flux: evaporation,  
 total runoff/streamflow

State variables: soil  
 moisture, soil  
temperature, skin  
temperature, snow  
 water equivalent, snow  
 cover

### NLDAS Validation: Fluxnet data sets

Monthly diurnal average surface latent and sensible heat flux: Chestnut Ridge, TN, 2008



latent sensible  
One of Ameriflux stations

forest tower 15



# Thanks for your attention!

## Welcome to use NLDAS products

### NOAA NLDAS Website

<http://www.emc.ncep.noaa.gov/mmb/nldas/>

### NASA NLDAS Website

<http://ldas.gsfc.nasa.gov/nldas/>

### Comments and Suggestions to:

NLDAS: [Youlong.Xia@noaa.gov](mailto:Youlong.Xia@noaa.gov), [Michael.Ek@noaa.gov](mailto:Michael.Ek@noaa.gov)

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